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OCEANOGRAPHY.—*The applications of science and engineering in the work of the United States Lighthouse Service.*[1] GEORGE R. PUTNAM, Lighthouse Service, Department of Commerce.

The Lighthouse Service has a definite function to perform, the providing of marks or signals to guide vessels in their proper course and to keep them away from danger. In performing this duty it makes extensive use of apparatus and appliances developed through scientific research, and of structures, both on land and afloat, in many cases involving difficult engineering problems. The aids, over 16,000 in number, are either on unfixed or floating structures, slightly more than half being floating. As to character, they fall into three general groups, lights, fog signals, and daymarks, though many aids combine these three functions or two of them.

Lighthouses and other lighted aids.—Though in many respects the fog signals are the aids most needed by the mariner, yet the lights are the more numerous and more widely known marks, and their development will be first described.

The outermost lights are those of the outside lightships, which are in effect floating lighthouses anchored off the coast and in the approaches to the great seaports. These are few in number, only 22 for the Atlantic, Gulf and Pacific coasts, but they are the guides most used by the larger class of vessels, as they can run directly for these lightships without risk of stranding if somewhat off in reckoning. An example is the Nantucket light vessel, anchored 41 miles off the land; this is the mark for which most of the vessels crossing the north Atlantic direct their course westward bound. There are now also a number of large sea gas buoys anchored off the coast and entrances.

The primary coast lights are the principal lighthouses marking prominent headlands, offlying islands and rocks, important entrances, and some intermediate points. On a well lighted coast these primary

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lights are so spaced that a vessel skirting the coast will always be in sight of one of these lights.

There are a great number of smaller lights, such as gas buoys marking channels and immediate entrances, and lighthouses and post lights marking minor entrances, inside channels, dangers, and river channels.

The problems to be solved in providing an effective light for the mariner are: most useful location, suitable illuminant, lamp and optical arrangement to give the required luminous range, height of the light for the proper geographic range, and distinctive characteristic to avoid confusion with other lighted aids as well as lights for other purposes.

Because of expense involved, the number of lights must of course be restricted to the most essential locations. They are placed as near as practicable to the track of vessels, or to the outer limit of the danger to be marked; large expenditures have sometimes been made so as to place a lighthouse in the position most protective to shipping. The geographic range, depending on the height of the focal plane above sea level, is for the primary lights on low coasts about 20 nautical miles, this distance being sufficient for general navigational purposes. This requires a tower of from 150 to 200 feet, depending on the elevation of the observer on the ship. Adding another 100 feet to the height of a tower of 200 feet increases the distance of visibility only $3^1/_2$ nautical miles.

Illuminants and lighting apparatus.—For illuminant, the primary coast lights of this country now use kerosene burned in incandescent oil vapor lamps. In this lamp the kerosene, forced into the vaporizer by air pressure, is heated and vaporized, and is burned mixed with air under a mantle, which is thus brought to a brilliant incandescence. This lamp gives one candlepower of the bare light for about $^3/_4$ gallon of kerosene a year, as against 6 gallons a year per candlepower for the Argand wick lamp, thus increasing the illuminating efficiency of the oil about 8 times. As an example, when the oil vapor lamp was installed at Cape Hatteras lighthouse the power of the light was increased from 27,000 to 80,000 candles, and the consumption of oil was reduced from 2,300 to 1,000 gallons a year. Next to kerosene, acetylene gas is the most widely used illuminant, supplying nearly 1,000 lights in this service, for the most part unattended beacons on shore, and gas buoys. These are nearly all supplied with compressed gas dissolved in acetone, in tanks filled with a porous substance; the acetone has the

remarkable power of absorbing many times its own volume of gas. This makes a safe and economical system for unattended lights and buoys. Electricity is not generally used at primary lights because of expense, sufficient illuminating power being obtained at much less cost with the oil vapor lamp; electricity is, however, used with great advantage at some stations where supply of current is available, particularly at harbor stations where distant control is desirable, as a station at the end of a breakwater where the light may be controlled from the shore end. An automatic arrangement for exchanging lamps in case of burnout is used.

The early lighthouses were lighted with open fires, and tallow candles were used at the Eddystone light for more than a hundred years. Although lighthouses have aided the mariner for more than 2,000 years, most of the progress in illuminating apparatus and fog signals has been made during the last century. A hundred years ago coal fires and tallow candles had only recently been abandoned at important lighthouses in England, guns were still used as fog signals, and no outside lightship had yet been moored off the coast of this country. The French physicist, Fresnel, in 1822, a hundred years ago this year made the greatest single step in the improvement of illuminating apparatus by developing a built-up annular lens surrounded by rings of glass prisms, the central portions of which refract and the outer portions both reflect and refract the light from a single source lamp placed at the focus. This lens was for a fixed light, and its effect was to concentrate the light in a plane useful to the mariner, but distributed around the horizon. Great progress has since been made by the use of lenses constructed in panels, and rotated, thus concentrating the light in beams sweeping around the horizon, and showing to the mariner a flash or group of flashes with definite characteristic. Great illuminating efficiency and much reduced cost have been obtained with such apparatus, by using smaller lenses, concentrating the light through a small number of panels, and revolving at high speed. The latter is made possible by carrying the weight of the rotating lens in mercury in an annular trough. The following comparison shows the great advantage of the modern lens arrangement: At Seguin, Maine, with first order lens 72 inches in diameter, the light, which is fixed, has 22,000 candlepower. At Molokai, Hawaii, there is a second order two panel lens, 55 inches in diameter, revolving once in 20 seconds, and giving each 10 seconds a flash of 620,000 candlepower. At the latter the cost of oil per candlepower per year is only about $^1/_{30}$ of a cent. With the

most complete lenses about 60% of the light is rendered useful, the balance being lost at the top and bottom, and through absorption by the glass of the lens and lantern.

Most of the important lights, and a large proportion of all the lights, have distinctive characteristics, to avoid the serious danger of mistaking the identity of the light. Color is used to some extent, but is undesirable excepting for minor lights because of the large loss of light, about 60%, even with the most efficient color, red. Modern installations at important stations have distinctive characteristics through the use of revolving lenses. Older installations of fixed lights have been changed into occulting by the use of some form of moving shutter or screen, much less efficient optically than the revolving lens, as the light is not concentrated into beams. Acetylene gas and electricity lend themselves to efficient arrangements for flashing lights. With the former, a small pilot flame burns continuously, and an ingenious flashing device discharges a supply of gas from the tank at uniform intervals of time.

Fog signals.—Fog and other conditions rendering objects invisible constitute the greatest menace to safety of shipping, and call for every help that science can give to vessels thus imperiled. The development of fog signals has lagged much behind the improvement of lighted aids. The first fog signals in this country were guns, fired occasionally and it was a hundred years after the building of Boston lighthouse before a fog bell was installed on our coast, and not until about 60 years ago were the first air and steam signals used, and it is only recently that a system has been developed permitting the taking of bearings on invisible signals, by means of the radio compass and radio signals.

The conditions as to fog differ greatly in different regions; the North Atlantic coast of the United States and portions of the Pacific and Alaska coasts are extremely foggy, while on the South Atlantic and Gulf coasts and in Porto Rico and Hawaii there is little fog. The highest record of fog for a year is 2,734 hours, or 31% of the total time, at Seguin Light Station, Maine. There is a record of $7\frac{1}{2}$ days of continuous fog at a station, requiring the operation of a fog signal 181 hours without cessation. The distribution of fog signals along the coasts, of course, conforms to the conditions as to amount of fog, as well as the intricacy and importance of navigation. Thus along the Atlantic coast north of Cape Lookout are located 334 fog signals (exclusive of sounding buoys), or considerably more than half of those maintained by this Service.

The radio fog signal is believed to be the most valuable of the future, because it is the first fog signal permitting of the taking of accurate bearings and effective at considerable distances. It was made possible by the development of the radio compass or radio direction finder at the Bureau of Standards. The system consists of equipment installed at lighthouses or on light vessels, for sending out radio signals of a distinctive character, and of radio compasses mounted on ship board, with which bearings of the radio signals may be taken. The compass coil mounted on the ship consists of a few turns of wire in a vertical plane, mounted over a magnetic compass or a graduated arc on which bearings can be read, and with receiving and amplifying devices. The coil rotates about a vertical axis, and when the plane is parallel to the direction of the signal the intensity of the sound is a maximum, and when it is perpendicular to the direction the signal is a minimum. The latter condition is used in taking bearings. Radio compasses, mounted on tenders of the Service, are now being regularly used in navigation. The Lighthouse Service has a number of radio fog signals in operation, and others are being established.

The Navy as a result of experience developed during the war, has established along the coast a number of radio compass stations, operating as a part of its coast communication system, and prepared to give bearings to vessels asking for same, this being the reverse of the Department of Commerce system providing for having the radio compass on the ship.

The fog signals at present in general use give warning by sound transmitted through the air; they are sirens, diaphones, and horns operated by compressed air, steam whistles, and bells actuated by weights and clockwork. There are also bells struck under the water operated by compressed air or electricity, which transmit sounds through the water, and there is now under test a more powerful apparatus of this sort, an oscillator, consisting of a heavy steel disc, which is set in vibration by electric power.

The sound in air fog signals is the aid very widely used throughout the world at the present time to warn and guide vessels in fog and other periods of low visibility. It has the advantage of simplicity of observation, being available, within its range, to every person of normal hearing. Although a somewhat crude solution of the navigational problem, it has undoubtedly immensely aided and safeguarded the movement of the shipping of the world. It has serious drawbacks as an aid to navigation, however. The distance at which even the most

powerful sound in air signals may be heard varies greatly, and under unfavorable weather conditions such signals can be heard only at a moderate distance, affording scant protection; there are many cases of aberration of the sound, the signal being lost and again picked up at a greater distance, and no means are available to the ordinary navigator of taking a definite bearing on a sound fog signal.

The steam whistle is a fog signal formerly extensively used; an important objection to it is the time required to get it in operation, as fog may come with but brief warning and the signal should be in operation at once. The most effective sound-producing fog signals are the siren and the diaphone using compressed air supplied by air compressors, driven by internal combustion engines. These signals have distinctive notes, and can be started very quickly on the approach of fog. In the standard form of siren now used in the Lighthouse Service, a hollow cylinder or rotor, 6 inches in diameter with peripheral slots is revolved in a casing with similar slots, leading to a horn or trumpet. The blasts are controlled by clockwork, giving a characteristic signal at each station. The diaphone is an instrument similar to the siren, but having a reciprocating motion instead of a rotary one.

Sounding buoys, operated automatically by the sea, are much used aids, and serve a very valuable purpose within moderate distances. The greater number are the familiar bell buoys; a modification of this has recently been made, obtaining a chime effect by means of several sizes of gongs, with clappers striking alternately. Bell buoys are so balanced as to operate with every slight motion of the waves. The whistling buoy is an American invention, and is a valuable aid where there is sufficient sea to operate it effectively. Submarine bells have been installed on buoys, the movement of the buoy operating a large vane, which winds a spring actuating the striking mechanism. The most valuable recent improvement is the installation on a buoy of a bell operated by carbonic acid gas. The gas tanks are placed in receptacles in the buoy, and the bell is struck at uniform intervals by a piston actuated by the gas pressure.

About half a century ago considerable research work in sound as affecting fog signals was done by Joseph Henry, then chairman of the Lighthouse Board, as well as Secretary of the Smithsonian Institution, and the results were collected in the latter's report for 1878. About 20 years ago elaborate comparative tests of fog signal apparatus were conducted by the Trinity House of London, at St. Catherines Point,

Isle of Wight, with the advice of Lord Rayleigh. In recent years comparative tests of apparatus have been made by the Lighthouse Service from time to time, and the fog signal station at Execution Rocks in Long Island Sound has recently been fitted up for systematic tests.

Lighthouse construction and engineering.—Unusual engineering problems are involved in the lighthouse work both in the fixed and floating structures. Most of the important lighthouses have been built on exposed sites, and many on submarine sites, or partially submerged reefs, involving difficult engineering design and construction. The problems will be illustrated by a few examples. Minots Ledge lighthouse, south of Boston, was built on a reef bare only at low water and for a small area, and exposed to the Atlantic. The reef had to be cut to receive the foundation of the tower; during the first year only 130 working hours were obtained on the rock, and the work was prosecuted for more than 3 years before a single stone was laid. After 5 years' work a massive stone tower was erected, which has now stood for over 60 years; on occasions the waves go over the top of the tower, 97 feet above the water.

On the Pacific coast, a notable lighthouse is that at Tillamook Rock, south of the mouth of the Columbia River. Here the top of the rock had to be blasted off to give a site for the structure, and special protection had to be provided for workmen and materials, as in storms the waves go over the entire rock. The lantern of the completed structure is 133 feet above the sea, but in severe storms rocks have been thrown through the lantern glass.

A number of lighthouses have been erected in open water on sand bottom, with caissons sunk by the pneumatic process. The first so built in this country was the Fourteen Foot Bank lighthouse in Delaware Bay, standing in 20 feet of water. The caisson was sunk to a depth of 33 feet into the sand, using a timber working chamber 40 feet square.

Marking the edge of the Florida reefs are six tall iron lighthouses, five of which stand in shallow water. As the material of the coral reefs was not solid enough to sustain on piles alone the weight of these towers, from 115 to 160 feet in height, sufficient support was obtained by driving wrought iron piles into the coral, to a shoulder resting against iron discs 8 feet in diameter, giving a large bearing on the surface of the coral.

Vessels and floating aids.—More than half of the aids maintained are floating, and these are of great value to mariners, as they can be

placed directly at the point most useful in marking a danger, or in defining a safe course; they have the disadvantage of being liable to be displaced or sunk, but this is to some extent overcome by improved design, heavier moorings, and constant watchfulness by the Lighthouse Service vessels and people.

The Service has about 120 vessels in commission, light vessels or floating lighthouses, and tenders, or supply steamers. Both of these classes require vessels of special design. Important problems of naval architecture have to be solved, particularly in the plans for the light vessels. This country maintains these on 49 stations, of which 22 are exposed stations in the open sea. To remain anchored on a station off the coast, exposed to the full force of storms, is a service not expected of any other ship, and for a long time difficulty was had in designing vessels that would meet the requirements. It was 73 years from the first attempt before a lightship was successfully maintained on Diamond Shoal off Cape Hatteras, and because of this difficulty elaborate attempts involving possible large expenditures, were made to build a lighthouse on the Outer Diamond Shoal. In the design of lightships, the lines are shaped to control the rolling and the easy riding of the vessel in a seaway. The framing is heavy, and ample water-tight bulkheads are provided. Flush deck construction is used with a minimum of upper works, so as to allow seas to sweep over the vessel. The bow is high to ride the seas. The largest light vessels in this Service are only about 135 feet in length. They are moored with mushroom anchors up to 7500 pounds in weight on the exposed stations, with heavy mooring chains, 180 fathoms or 1,080 feet in length, weighing approximately 28,000 pounds. The chain passes through a hawse pipe in the stem, near the water line, so that the vessel may ride as easily as possible. Lightships anchored in the more exposed positions are subjected to most severe treatment by the combination of gales and cross currents, and every precaution is taken to secure their safety, and their remaining on station. The modern vessels are self-propelled, and the strain on the mooring chains during storms is relieved by judicious use of the propelling machinery. At a few stations a spherical mooring buoy is shackled to a submerged portion of the chain to carry a part of the weight and ease the strains due to the vessel surging.

The lighthouse tenders are the supply and construction vessels, and care for the buoys and lightships. They are equipped with powerful hoisting gear for handling the heavy buoys and moorings,

and have large open deck space forward for the stowage of buoys. They must be of moderate draft so as to go into close waters to place the buoys, and at the same time must be good sea boats, for their work takes them out to sea, some times under severe weather conditions.

The Service maintains many types of buoys, of which the most important are the lighted buoys, and the sounding buoys, already mentioned. The other buoys are of iron or wood, and indicate by their color and number their position with respect to the channel.

Problems in Alaska.—There are special problems to be met in some regions, as for instance Alaska. Here water navigation is very important, as the territory is largely dependent on it for transportation, and the conditions as to fog, reefs and rock-bound coasts, and water depths render navigation difficult. The remoteness makes lighthouse maintenance expensive, particularly for attended stations, and because of the very extensive coast line as complete a system of aids as on the North Atlantic coast would be beyond the financial resources of the government. In the past 12 years the number of aids in Alaska has been increased more than threefold, and many lights, suitable for the inside passages, have been added at moderate maintenance expense by the installation of acetylene gas apparatus. Important additions are still needed, particularly in the way of fog signals.

The U. S. Lighthouse Service.—In closing I will briefly refer to the Lighthouse Service in general. It lights and marks all the coasts and interior navigable waters of the United States and its possessions excepting the Philippine Islands and Panama. It maintains 16,000 aids to navigation and is the most extensive service of its kind in the world under one organization. It is conducted through 19 lighthouse districts, each under a Superintendent, who is charged with a wide local responsibilty for the proper upkeep of the district. The responsible officers of the Service are engineers or other technical men, with long experience in the work. There is on Staten Island, New York Harbor, a general supply station, and shops where considerable special equipment is manufactured for the Service, and where some tests and experimental work are carried on. The Service makes very extensive application of the results of scientific research, but it has, however, not attempted to establish any large research division, because of the existence in the Department of Commerce of the Bureau of Standards, and the excellent assistance and cooperation given by that organization.

The first lighthouse in this country was built by Massachusetts at Boston, in 1716, and this station is still in operation. Several other lighthouses were built by the colonies. The maintenance of the lighthouse system was the first public work, or work of a technical character, undertaken by the United States Government, being provided for at the first session of Congress in 1789.

CRYSTALLOGRAPHY.—*Crystallographic-optical properties of calcium fumarate and maleate.*[1] EDGAR T. WHERRY and RAYMOND M. HANN, Bureau of Chemistry.

Crystals of these salts do not appear to have been measured heretofore. They are, however, of interest in that the acids represent a simple case of stereoisomerism, so we have prepared them and studied them in detail.

CALCIUM FUMARATE, $Ca(C_4H_2O_4).2H_2O$

Preparation.—The fumaric acid was obtained from a commercial firm now making it in a high state of purity by a catalytic process. After several trials the following plan was found to yield the best crystals of the calcium salt: Dissolve $2^1/_2$ grams of fumaric acid in 50 cc. of water, heat to boiling, neutralize with 30% KOH solution, and then acidify slightly by the addition of a small amount of the acid. To the boiling solution add an equal volume of 5% $CaCl_2$ solution and continue boiling until a slight turbidity appears. Filter the solution, cover loosely and allow to stand for several weeks. Groups of blade-like crystals as much as 2 mm. in length then separate out. Before removing them for study the solution is best placed in a cold place for a time to cause the crystals to take up material and repair any corrosion which their faces may have suffered.

Composition.—On ignition the salt was found to yield a residue of CaO equivalent to 28.47%, indicating the presence of 2 molecules of water of crystallization (theory, 29.5%).

Crystallography.—It was found that where crystals lay close together in groups their angles were somewhat distorted, but it was possible to pick out several fairly free from such disturbances, and five of these were submitted to crystallographic measurement. They are orthorhombic and tabular on a pinacoid, with marginal dome-prism forms.

In an orthorhombic crystal a choice of six orientations is open to the

[1] Contribution from the Analytical Reagents Investigation Laboratory and Laboratory of Crystallographer. Received May 20, 1922.

describer; and in the present substance the single pinacoid present might be made either *a*, *b*, or *c*, while in each of these cases the dome-prism forms might be placed in either of two positions. The conventional rule about such matters is to place the direction of greatest elongation vertical, and make a dominant pinacoid face *b*. When this is done for calcium fumarate, its angle data come out as shown in Table 1.

TABLE 1.—ANGLES OF CALCIUM FUMARATE IN CONVENTIONAL ORIENTATION.
Orthorhombic; $a : b : c = 0.3970 : 1 : 0.3772$ ($p_0 = 0.9503$; $q_0 = 0.3772$).

Number Letter	Symbols Gdt.	Mill.	Description	Angles φ	Observed ρ
1 b	0∞	010	Dominant form	0°00′	90°00′
2 m	∞	110	Longer marginal form	68°21′	90°00′
3 q	01	011	Shorter marginal form	0°00′	20°40′

It may be noted that this substance lies very near to the mineral columbite, $FeCb_2O_6$, which, in corresponding orientation, has $a : b : c = 0.4023 : 1 : 0.3580$.

There is, however, another method of orientation which in many respects seem preferable, namely, that worked out by the late Professor E. S. Fedorov.[2] Unfortunately his rules have not yet been made available to non-Russian readers in complete form. The first step seems to be to bring the crystal into that orientation which shall show most clearly its relationship to a system of higher symmetry. In the present case, it takes but brief inspection of the habit to realize that this substance approaches the tetragonal system if the large pinacoid is made the base, and this is the orientation adopted for the second angle table. The substance is, in fact, as far as the angles go, markedly peritetragonal. According to Fedorov,[3] the tabular habit perpendicular to axis *c* indicates that the axial ratio should be strongly positive—that is, axis *c* should be much greater than the others. As a matter of fact, whichever axis is taken as *b*, the value of *c* is greater than $2^1/_2$, so that thus far the relations are normal.

Next there is a choice between making the dome with the smaller rho angle the side dome or the front dome; in the former position, axis *a* would be less than axis *b*, in the latter, greater than *b*. Since *b* is by convention taken as the unit axis, it seems preferable to make *a* greater than *b*, and as this also agrees with Fedorov's rule, the greater elongation of the crystal being toward the greater rho, the dome with the smaller rho angle has been turned to the front, that is, made form (101). The dome with the larger rho angle then becomes (011), and

[2] *Z. Kryst. Min.* **50**: 513. 1912.
[3] *Loc. cit.*

the axial ratio given at the head of the angle table is the result. Fedorov termed the orientations worked out on the basis of his rules the "correct setting," but any one of the six orientations of an orthorhombic crystal is just as correct as any other, so the term "significant" is preferred, since what is meant is that orientation which best brings out the relations of the crystal to other systems.

TABLE 2.—ANGLES OF CALCIUM FUMARATE IN SIGNIFICANT ORIENTATION

Orthorhombic; $a : b : c = 1.0523 : 1 : 2.6510$ ($p_0 = 2.5193$; $q_0 = 2.6510$). Peritetragonal, with deviation of prism angle φ from the tetragonal value = 1°28′.

Number letter	Symbols Gdt.	Mill.	Description	Angles φ	Observed ρ
1 c	1	001	Dominant form	....	0°00′
2 e	01	011	Narrow but brilliant	0°00′	69°20′
3 d	10	101	Like e, but longer	90°00′	68°21′
....	1	111	(Calculated)	43°32′	74°43′

The crystals are usually distorted in such a manner that one dome face of each pair is decidedly larger than the other, the symmetry being thus ecto-hemimorphic. Their average habit is shown in Figure 1.

Space relations.—The topic axes of the substance were next calculated. As the usual plan for doing this obscures the relations somewhat, it becomes preferable to first calculate unit-volume axes, which differ from the usual crystal axes in that axis b is no longer taken as unity, but is reduced to such a value that the product of all their axes equals one. The unit volume axes may be distinguished from the ordinary axes by the use of capital letters. The formulas used are: $A = \sqrt[3]{a^2/c}$; $B = A/a$; $C = c \times B$. Using the values obtained from the significant orientation of Table 2, the results are: $A : B : C = 0.7475 : 0.7104 : 1.8832$.

The molecular weight of calcium fumarate, $Ca(C_4H_2O_4).2H_2O$, is 190.1. Its specific gravity was determined by suspending a few crystals in a mixture of carbon tetrachloride and bromoform, the amounts of the constituents being varied until the crystals remained suspended, when the specific gravity of the liquid was obtained with a Westphal balance. As variation from one crystal to another was shown, some floating in the same liquid in which others sank, it would be meaningless to state the result beyond the second place; it was 1.71 ± 0.01. The molecular volume is accordingly 111.2 and the cube root of it 4.81. Multiplying the unit-volume axes by this factor, the topic axes are: $\chi : \psi : \omega = 3.60 : 3.42 : 9.06$.

Optical properties.—Study by the immersion method under the polarizing microscope shows calcium fumarate to be biaxial negative

with a small axial angle, but extreme double refraction. It has the form of rectangular plates and irregular angular fragments, with refractive indices of $\alpha = 1.413$, $\beta = 1.602$ and $\gamma = 1.611$, all ± 0.003. The double refraction is thus 0.198, and $2V$ calcd. = 22°24′, $2E$ calcd. = 36°16′, $2E$ obs. = 37° ± 1°. The optical orientation, however, is not what might have been expected from the peritetragonal crystal form; for $X = a$, $Y = b$ and $Z = c$, so that perpendicular to the pinacoid it is not the acute but the obtuse bisectrix which is visible.

The mean refractive index $n = 1.539$, from which the refractivity may be derived, using the formula $M = V \times (n^2 - 1)/(n^2 + 2)$ (V being molecular volume, already determined). This gives $M = 34.8$, the significance of which value is discussed after the data for calcium maleate are given.

CALCIUM MALEATE, $Ca(C_4H_2O_4).H_2O$

Preparation.—A number of unsuccessful attempts were made to prepare this salt in a form suitable for crystallographic measurement, but the crystals were in general too minute to handle. After experimenting to determine the best strengths of the solution to employ, the following plan was adopted, the acid used coming from the same source as the fumarate: Dissolve 5 grams of maleic acid in 50 cc. of H_2O, heat to boiling, neutralize with 30% KOH solution, and slightly acidify with additional acid. To the boiling solution add an equal volume of boiling 10% $CaCl_2$ solution, and continue boiling until the slight bumping which often precedes precipitation is noticed. Filter rapidly into a vessel kept at about 80°, by immersion in a large water bath, cover closely and allow the bath to cool. When cooling is rapid, rosette groups of needle-like crystals form; when it is gradual, a continuous crust, which ultimately develops into interlacing needles, deposits. After some days the vessel is placed on ice for a time and the crystals are removed and dried.

Composition.—On ignition the salt was found to yield a residue of CaO equivalent to 32.38%, showing the presence of one molecule of water of crystallization (theory 32.6%).

Crystallography.—The crystals obtained are not altogether satisfactory, for although the prism faces are fairly well developed and do not give excessive variation in angles, the terminations seem always to be dull or rounded. However, by measuring ten crystals and taking the average values of the angles a fairly close approximation to the probable values could be obtained. It is noteworthy that the more

rapidly cooling crystals had a series of steep domes forming a more or less continuous curve, while those that cooled more slowly had but a single flat dome. The system, as with the fumarate, is orthorhombic. In standard orientation, placing the direction of elongation vertical and the pinacoid at the side, the angles of Table 3 are obtained.

TABLE 3.—ANGLES OF CALCIUM MALEATE IN STANDARD ORIENTATION

Orthorhombic; $a : b : c = 0.779 : 1 : 0.643$ ($p_0 = 0.825$; $q_0 = 0.643$).

Number letter	Symbols Gdt.	Mill.	Description	Angles φ	Observed ρ
1 b	0∞	010	Narrow and sometimes lacking	0°00′	90°00′
2 m	∞	110	Dominant form	52°05′	90°00′
3 q	01	011	Principal termination	0°00′	32°45′
4 r	06	061	Part of long curved form	0°00′	76°±
5 s	08	081	Part of long curved form	0°00′	79°±

This is close to the mineral chalcostibite (wolfsbergite), $CuSbS_2$, which has $a : b : c = 0.8026 : 1 : 0.6275$.

In this case as before the standard orientation is not the significant one, for the prism angle is over 7° away from the theory for the tetragonal, while the principal dome has a phi angle less than 3° away from the theory for a more symmetrical system, in this case the hexagonal. Turning the pinacoid to the front, in order to make axis b the shortest one, this gives the angles and axial values of Table 4 and Figure 1.

TABLE 4.—ANGLES OF CALCIUM MALEATE IN SIGNIFICANT ORIENTATION

Orthorhombic; $a : b : c = 1.555 : 1 : 1.211$ ($p_0 = 0.779$; $q_0 = 1.211$). Perihexagonal, with deviation of prism angle φ from theory for hexagonal 2°45′.

Number letter	Symbols Gdt.	Mill.	Description	Angles φ	Observed ρ	Calculated φ	Calculated ρ
1 a	∞ 0	100	Narrow and sometimes lacking	90°00′	90°00′	90°00′	90°00′
2 k	8∞	810	Part of long curve	79°±	90°00′	79°00′	90°00′
3 l	6∞	610	Brightest part of long curve	76°±	90°00′	75°28′	90°00′
4 m	∞	110	Principal terminal form	32°45′	90°00′	(32°45′)	90°00′
5 d	10	101	Dominant form	90°00′	37°55′	90°00′	(37°55′)
...	1	111	(Calculated)	....	....	32°45′	55°13′

Space relations.—Calculating the unit-volume axes as before, the results are: $A : B : C = 1.259 : 0.810 : 0.981$. The specific gravity, determined by the same method as in the preceding case, was decidedly greater, 1.84 ± 0.01. The molecular weight being 172.1, this gives the molecular volume 93.5 and its cube root 4.54, making the topic axes $\chi : \psi : \omega = 5.72 : 3.68 : 4.45$. No relation can be traced with the corresponding values for the fumarate.

Optical properties.—Calcium maleate is like the fumarate biaxial and negative, but its refractive indices are much higher and the double

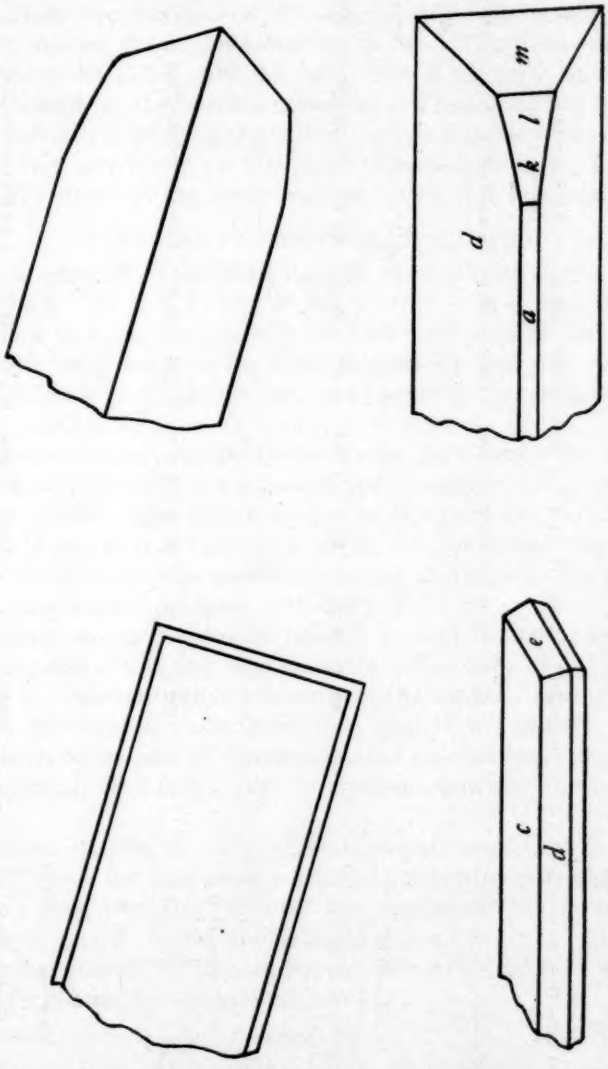
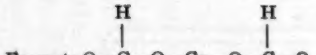
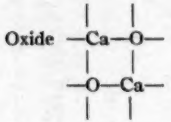
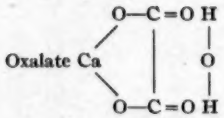
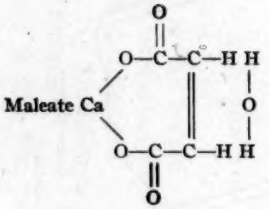
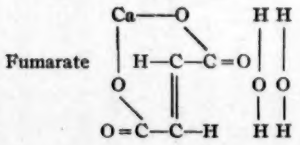


FIG. 1. *Lower figures*, calcium fumarate; *upper figures*, calcium maleate.

TABLE 5.—REFRACTIVITY DATA FOR CALCIUM SALTS

Compound formula	Mol. wt.	Sp. gr.	Mol. vol.	Mean n_D	$\frac{n^2-1}{n^2+2}$	Refractivity, M_D. Obs.	Elements	Structure
 Formate	130.1	2.02	64.4	1.510	0.299	19.3	C+O+H=14.4; diff.=Ca=4.9	0
 Oxide	56.1	3.31	16.9	1.830	0.439	7.4	Ca+O=7.1	0.3
 Oxalate Ca	146.1	2.23	65.5	1.564	0.325	21.3	Ca+C+O+H=20.8	0.5
 Maleate Ca	172.1	1.84	93.5	1.571	0.329	30.8	Ca+C+O+H=27.8	3.0
 Fumarate	190.1	1.71	111.2	1.539	0.313	34.8	Ca+C+O+H=31.5	3.3

refraction weaker. It appears under the microscope in rods or fragments, with the indices: $\alpha = 1.495$, $\beta = 1.580$, $\gamma = 1.640$, all ± 0.003, making the double refraction 0.145. The axial angle $2V$ is calculated to be 77°36′, and $2E$ 164°; this is too great an angle to be determined by the immersion method. The orientation is $X = c$, $Y = a$, and $Z = b$, so, as in the case of the fumarate, the longer crystal axes do not correspond to the lesser refractive indices. The mean $n = 1.571$ gives, on the same basis as before, the refractivity 30.8.

DISCUSSION OF THE REFRACTIVITY DATA

The refractivities of the elements other than calcium used are those of Eisenlohr:[4] $C = 2.4$, $O{=} = 2.2$, ${-}O{-} = 1.5$, and H = 1.1. In calcium formate two entirely separate acid radicles are present, so the difference between the total refractivity and that calculated for the elements of the radicle may be regarded as the normal value for calcium. It is 4.9.

In calcium oxide X-ray study has shown the atoms to be arranged as shown, with directions of attraction (electrostatic) also perpendicular to the paper. This represents but little strain, and the additional refractivity due to the structure is slight. In the oxalate the calcium unites the two ends of the radicle into a ring, and as would be expected this produces a slightly higher extra refractivity.

In calcium maleate a double bond is present, which according to Eisenlohr produces in any case an extra refractivity of 1.0; but in addition the calcium unites two ends of the radicle. The ring produced in this case is much larger than that of the oxalate, and the double bond forms part of the ring, so that an additional strain must be represented; and this is seen to produce an excess of refractivity of 2.0.

The most complex of all of the compounds considered is calcium fumarate, which not only has the calcium uniting the ends of the radicle into a ring, but also, because the position of the substituting groups with respect to the double bond, has an irregular ring. Still more excess refractivity than in the maleate would be expected, and as a matter of fact the calculation gives 2.3.

SUMMARY

The preparation and crystallographic-optical properties of calcium fumarate and maleate are described. Both are orthorhombic, but they show no definite space relationships. From a calculation of the

[4] Spektrochemie Organischer Verbindungen, p. 48. 1912.

refractivities it appears that their peculiar structures lead to a definite extra refractivity, greater in the case of the less symmetrical fumarate.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

BIOLOGICAL SOCIETY

632D MEETING

The 632d meeting of the Biological Society was held in the auditorium of the National Museum, at 8 p.m., on Jan. 4, 1922, in cooperation with the Audubon Society and the Wild Flower Preservation Society, with President BAILEY in the chair. Mr. STEPHEN T. MATHER, of the National Park Service, introduced the speaker of the evening, Mr. ARTHUR C. PILLSBURY, official photographer of the Yosemite National Park.

Mr. Pillsbury's subject was *Wild flowers and birds of Yosemite National Park*. It was illustrated with moving pictures showing birds, flowers, and scenery of Yosemite Park. A striking feature was the exhibition of some twenty or more series of pictures showing the opening of the buds of as many different kinds of flowers; the exposures were taken at fifteen minute intervals, so that as projected on the screen the opening was accelerated several thousand times.

633D MEETING

The 633d meeting of the Biological Society was held in the lecture hall of the Cosmos Club on Jan. 21, 1922, with President BAILEY in the chair.

The following persons were elected members: Miss LUCY HOWARD, HAROLD M. VARS, HERBERT F. PRYTHERCH, and ARTHUR H. FISHER. The President appointed Messrs. ROHWER, JACKSON, CHAMBLISS, and COKER as a Committee on communications.

Under general notes, Dr. R. W. SHUFELDT exhibited a new biography of the well known British ornithologist ALFRED NEWTON, by WOLLASTON. Dr. SHUFELDT showed lantern slides of Professor Newton from several pictures, also some other slides illustrating the biography.

Mr. HOFFMAN showed a specimen of *Attacus edwardsii*, one of the largest known moths, from India.

Major GOLDMAN reported having attended an organization meeting of the Boston Bird-Banding Society, which recently occurred.

Mr. WILLIAMS reported hundreds of starlings congregating and roosting on the Hughes Building near the Cosmos Club, as many as 400 or 500, he estimated. They seem to chirp all night.

The following program was given:

S. F. HILDEBRAND: *Fish in relation to mosquito control.*

The speaker had been employed in the summer of 1921 to introduce fish into mosquito-breeding waters about Savannah, Ga.

The top minnow, *Gambusia affinis*, is altogether the best fish for introduction, although all small fish will feed on mosquito larvae under favorable conditions. The top minnow is viviparous, hence does not have complicated nesting habits to be taken into consideration. It is a prolific and hardy fish and never outgrows the mosquito-eating size. With the aid of a large number of lantern slides the speaker discussed the effect of various kinds of vegeta-

tion in the water in protecting or screening the larvae from the fish, as well as other factors having an influence upon the matter.

Major GOLDMAN asked if the top minnow could be introduced outside its normal range. The speaker said it has winter-killed in the Mississippi Valley to a considerable extent.

President BAILEY remarked that lily pads are eaten by beavers, and silver grass by muskrats, which would reduce the mosquito protection where these animals occur.

H. L. SHANTZ: *Notes on the white ants of Africa.*

The speaker in his extensive explorations of Central and South Africa had continually come into contact with termite nests, as they are generally conspicuous objects. They tell the color of the soil at a glance. There are many types, which were illustrated with lantern slides, some colored. Where large hills stand a long time and disintegrate, the earth is richer than elsewhere, and natives select such places for cultivation.

Discussed by Mr. ROHWER and Mr. WHITE, who compared the local species about Washington, in their aversion to light, etc. Mr. White said the local species are very beneficial on his farm by eating out stumps, which thus decay much more rapidly; a 4-inch stump is often eaten almost wholly out in a year. They damage apple trees where wounds occur, making a mud tunnel up the bark.

Major GOLDMAN recalled the statement in Drummond's *Tropical Africa*, that termites there perform for the soil a service like that of earthworms in temperate countries, passing the soil through their bodies and enriching it.

Dr. SHUFELDT described the orientation of a true ant at Savannah, with reference to its path.

C. DWIGHT MARSH: *Live stock poisoning by death camas.*

Stockmen on the western stock ranges suffer very heavy losses of sheep from poisonous plants. Probably of all the plants those which cause the greatest destruction are those commonly known as death camas, which are species of the botanical genus *Zygadenus*. Losses of hundreds of sheep within 24 or 48 hours are not at all unusual. These plants have been known to be poisonous for nearly a century, but definite knowledge in regard to their properties has only been acquired within the last 20 or 25 years. The plants poison horses and cattle as well as sheep, but the principal losses have been of sheep.

Death camas grows widely distributed over the ranges from the Rocky Mountains westward.

The U. S. Department of Agriculture has made detailed studies of death camas poisoning, and it was assumed that all forms of the plant were about equally poisonous. Recent studies, however, have brought out important facts in regard to their relative toxicity.

There are four common species of death camas on the western ranges, and it has been found that two are much more poisonous than the others, while one species that has always been considered dangerous has so little toxicity that probably under range conditions it never causes any losses. The most poisonous species is without doubt that growing in Montana and Wyoming. A California species is equally injurious as far as causing sickness is concerned, but produces fewer deaths. The results of the studies made have indicated clearly the comparative danger from these species and have also shown what measures can be taken to avoid losses.

634TH MEETING

The 634th meeting was held at the Cosmos Club on Feb. 4, 1922, with President BAILEY in the chair and 55 persons present.

Under *Brief notes*, Dr. L. O. HOWARD said that he had noticed in the Annals of Tropical Medicine and Parasitology for September 30 last an illustration showing a botfly larva attached to a tapeworm, but there was no reference to it in the text. He wrote to Professor ROBERT NEWSTEAD of the Liverpool School of Tropical Medicine, inquiring about the specimen figured; Professor Newstead consulted with one of the authors of the paper, Professor YORKE, who stated that the larvae were found by him attached to tapeworms *in the stomach of the zebra*. Professor Yorke gave specimens to Professor Newstead, who with great generosity forwarded them to Dr. Howard, who exhibited them to the Society. He said the case, so far as he could ascertain, is unique. Dr. B. H. RANSOM had told him that once, when collecting in Canada, he had put some tapeworms and some Oestrid larvae in the same vial and had later found that the Oestrids had destroyed the tapeworms as specimens. In the present case, however, the larvae became attached to the tapeworms in the zebra's stomach and presumably while both were alive. The tapeworm was identified as *Anoplocephala rhodesiensis* and the bot larva as *Gastrophilus pecorum* variety *zebra* Rod. and Beq.

Dr. T. S. PALMER reported the recent census of the quail in the District of Columbia, made by the police, who had fed the birds during the period of deep snow, the food being furnished by the Audubon Society. The census showed over 100 covies in the District, with a total of approximately 2095 birds.

President BAILEY reported that buffalo bones had been received recently from a cave in Malheur Co., Oregon, east of Malheur Lake, the locality being about 100 miles further west than any other authentic evidence of the occurrence of buffalo heretofore. Indian tradition, however, indicates that they once occurred about 50 miles further west than this cave.

The first paper of the regular program was by SMITH RILEY, on *The Nation's game supply*, and was illustrated.

Dr. SHUFELDT mentioned the antelope as the most difficult animal to protect, as it persists in remaining on the plains. He once killed a mountain buffalo, considerably different from the plains form.

Dr. MARSH said elk are unpopular with stockmen, especially when it happens that they destroy haystacks and the owner is prevented by law from killing them. Major GOLDMAN thought the stockmen could be pacified by feeding the elk in winter so as to protect the cattle range.

The second paper of the evening was by A. H. HOWELL, on *The relationship and distribution of American chipmunks*. The paper was illustrated by skins of the animals, and by lantern slides in the form of maps with shading to show the areas covered by the different forms. There are in the east one species with four subspecies, while in the west there are five species with 57 recognizable subspecies. The western forms climb trees more than the eastern but are not actually arboreal.

Dr. PALMER said the group was universally called ground-squirrels in the early days, the word chipmunk dating only from 1842. The origin of the term he could not explain. He also mentioned that most of the species have been described by members of the Biological Society.

J. M. ALDRICH, *Recording Secretary*.